

WHAT IS CLAIMED IS:

1. A zoom lens comprising:
  - a first group optical system having a positive refracting power;
  - a second group optical system having a negative refracting
  - 5 power;
  - a third group optical system having a positive refracting power;
  - and
  - a diaphragm that moves toward an object side integrally with the
  - third group optical system, wherein
  - 10 the first group optical system, the second group optical system,
  - and the third group optical system are sequentially arranged from the
  - object side toward an image side,
  - at least the first group optical system and the third group optical
  - system moves in such a manner that a distance between the first group
  - 15 optical system and the second group optical system becomes minimum
  - at a short focal-length side, and a distance between the second group
  - optical system and the third group optical system becomes minimum at
  - a long focal-length side, and
  - the third group optical system includes a triplet lens formed by
  - 20 sequentially bonding a negative lens, a positive lens, and a negative
  - lens.
2. The zoom lens according to claim 1, wherein a trace of a
- movement of the first group optical system between the short
- 25 focal-length side and the long focal-length side makes a convex shape

opening to the object side.

3. The zoom lens according to claim 2, wherein the first group optical system is closest to the image side at a mean focal-length side  
5 between the short focal-length side and the long focal-length side.

4. The zoom lens according to claim 1, wherein the negative lens, closest to the object side, of the triplet lens is formed with a strong concave opening to the image side.

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5. The zoom lens according to claim 1, satisfying a relation  
$$0.6 < K_{12} / (f_w + f_t) < 1.2$$

where  $K_{12}$  is changing amount of a distance between the first group optical system and the second group optical system,  $f_w$  is a combined  
15 focal length of whole system at the short focal-length side, and  $f_t$  is a combined focal length of the whole system at the long focal-length side.

6. The zoom lens according to claim 1, satisfying relations  
$$-0.22 < N_p - N_n < 0 \text{ and } 3 < v_p - v_n < 36$$

20 where  $N_p$  and  $v_p$  are a refractive index and an Abbe constant of the positive lens of the triplet lens, respectively, and  $N_n$  and  $v_n$  are an average of refractive indexes and an average of Abbe constants of the two negative lenses of the triplet lens.

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7. The zoom lens according to claim 1, wherein the third group optical system further includes at least one positive lens at each of the object side and the image side of the triplet lens.
- 5 8. The zoom lens according to claim 7, wherein at least one positive lens from among the positive lenses arranged at the object side and the image side of the triplet lens is an aspheric lens.
9. The zoom lens according to claim 1, wherein each of the first  
10 group optical system and the second group optical system includes at least one positive lens and one negative lens.
10. A zoom lens comprising:  
a first group optical system that has a positive refracting power  
15 and does not move with zooming;  
a second group optical system that has a negative refracting power and moves from an object side toward an image side with zooming from wide-angle side toward telephoto side;  
a third group optical system that has a positive refracting power  
20 and moves from the image side to the object side with zooming from the wide-angle side toward the telephoto side; and  
a fourth group optical system that has a positive refracting power and does not move with zooming, wherein  
the first group optical system, the second group optical system,  
25 the third group optical system, and the fourth group optical system are

sequentially arranged from the object side toward an image side, and  
the third group optical system includes a triplet lens formed by  
sequentially bonding a negative lens, a positive lens, and a negative  
lens.

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11. The zoom lens according to claim 10, wherein the negative lens,  
closest to the object side, of the triplet lens is a negative meniscus lens  
having a meniscus shape with a concave opening to the image side.

10 12. The zoom lens according to claim 10, wherein the negative lens,  
closest to the image side, of the triplet lens is a negative lens with a  
concave opening to the image side.

13. The zoom lens according to claim 10, satisfying relations  
15  $1.45 < N_{c2} < 1.52$  and  $68 < v_{c2} < 85$   
where  $N_{c2}$  and  $v_{c2}$  are a refractive index and an Abbe constant of the  
positive lens arranged in the middle of the triplet lens, respectively.

14. The zoom lens according to claim 13, satisfying relations  
20  $1.60 < N_{c1} < 1.95$ ,  
 $20 < v_{c1} < 40$ ,  
 $1.60 < N_{c3} < 1.95$ , and  
 $20 < v_{c3} < 40$

where  $N_{c1}$  and  $v_{c1}$  are the refractive index and the Abbe constant of the  
25 negative, closest to the object side, of the triplet lens, respectively, and

$N_{c3}$  and  $v_{c3}$  are the refractive index and the Abbe constant of the negative lens, closest to the image side, of the triplet lens, respectively.

15. The zoom lens according to claim 10, satisfying a relation

5 
$$0.25 < (R_{c2}/R_{c4}) < 1.25$$

where  $R_{c2}$ , and  $R_{c4}$  are radiuses of curvatures on the object side and the image side of bonding surface of the triplet lens, respectively.

16. A zoom lens comprising:

10 a first group optical system that has a positive refracting power and does not move with zooming;

a second group optical system that has a negative refracting power and moves from an object side to an image side with zooming from wide-angle side toward telephoto side;

15 a third group optical system that has a positive refracting power and moves from the image side to the object side with zooming from the wide-angle side toward the telephoto side; and

a fourth group optical system that has a positive refracting power and does not move with zooming, wherein

20 the first group optical system, the second group optical system, the third group optical system, and the fourth group optical system are sequentially arranged from the object side toward an image side, and

the third group optical system includes

25 a triplet lens formed by sequentially bonding a negative lens, a positive lens, and a negative lens; and

at least one positive lens at each of the object side and the image side of the triplet lens.

17. The zoom lens according to claim 16, wherein at least one  
5 positive lens from among the positive lenses arranged at the object side and the image side of the triplet lens is an aspheric lens.

18. A zoom lens comprising:  
a first group optical system that has a positive refracting power  
10 and does not move with zooming;  
a second group optical system that has a negative refracting power and moves from an object side toward an image side with zooming from wide-angle side toward telephoto side;  
a third group optical system that has a positive refracting power  
15 and moves from the image side to the object side with zooming from the wide-angle side toward the telephoto side; and  
a fourth group optical system that has a positive refracting power and moves accordingly with zooming, wherein  
the first group optical system, the second group optical system,  
20 the third group optical system, and the fourth group optical system are sequentially arranged from the object side toward an image side, and  
the third group optical system includes a triplet lens formed by sequentially bonding a negative lens, a positive lens, and a negative lens.

19. A zoom lens comprising:
- a first group optical system having a positive refracting power;
  - a second group optical system having a negative refracting power;
  - 5 a third group optical system having a positive refracting power;
  - a fourth group optical system having a positive refracting power;
  - a fifth group optical system having a positive refracting power;
  - and
  - a diaphragm arranged at an object side of the third group optical
  - 10 system, wherein
  - the first group optical system, the second group optical system, the third group optical system, the fourth group optical system, and the fifth group optical system are sequentially arranged from the object side toward an image side,
  - 15 at least the second group optical system and the fourth group optical system move with zooming from short focal-length side toward long focal-length side, and
  - the second group optical system includes a triplet lens formed by sequentially bonding a negative lens, a positive lens, and a negative
  - 20 lens from the object side.
20. The zoom lens according to claim 19, wherein the negative lens, closest to the object side, of the triplet lens is a bi-concave lens.

21. The zoom lens according to claim 19, wherein the negative lens, closest to the image side, of the triplet lens is a bi-concave lens.

22. The zoom lens according to claim 19, satisfying relations

5  $1.70 < N_{c2} < 1.90$  and  $20 < v_{c2} < 40$

where  $N_{c2}$  and  $v_{c2}$  are a refractive index and an Abbe constant of the positive lens arranged in the middle of the triplet lens, respectively.

23. The zoom lens according to claim 22, satisfying relations

10  $N_{c1} < 1.62,$   
 $v_{c1} > 55,$   
 $N_{c3} > 1.65,$  and  
 $v_{c3} < 40$

where  $N_{c1}$  and  $v_{c1}$  are the refractive index and the Abbe constant of the  
15 negative, closest to the object side, of the triplet lens, respectively, and  
 $N_{c3}$  and  $v_{c3}$  are the refractive index and the Abbe constant of the  
negative lens, closest to the image side, of the triplet lens, respectively.

24. The zoom lens according to claim 19, satisfying a relation

20  $0.2 < (R_{c2}/R_{c4}) < 0.4$

where  $R_{c2}$ , and  $R_{c4}$  are radiuses of curvatures on the object side and the image side of bonding surface of the triplet lens, respectively.



25. The zoom lens according to claim 19, wherein a surface closest to the object side in the second group optical system is aspherical.

26. A camera comprising a zoom lens as a shooting optical system,  
5 wherein the zoom lens includes

a first group optical system having a positive refracting power;

a second group optical system having a negative refracting  
power;

a third group optical system having a positive refracting power;

10 and

a diaphragm that moves toward an object side integrally with the  
third group optical system, wherein

the first group optical system, the second group optical system,  
and the third group optical system are sequentially arranged from the

15 object side toward an image side,

at least the first group optical system and the third group optical  
system moves in such a manner that a distance between the first group  
optical system and the second group optical system becomes minimum  
at a short focal-length side, and a distance between the second group

20 optical system and the third group optical system becomes minimum at  
a long focal-length side, and

the third group optical system includes a triplet lens formed by  
sequentially bonding a negative lens, a positive lens, and a negative  
lens.

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27. The camera according to claim 26, wherein the camera is a digital camera.

28. A camera comprising a zoom lens as a shooting optical system,  
5 wherein the zoom lens includes

a first group optical system that has a positive refracting power and does not move with zooming;

a second group optical system that has a negative refracting power and moves from an object side toward an image side with  
10 zooming from wide-angle side toward telephoto side;

a third group optical system that has a positive refracting power and moves from the image side to the object side with zooming from the wide-angle side toward the telephoto side; and

a fourth group optical system that has a positive refracting  
15 power and does not move with zooming, wherein

the first group optical system, the second group optical system, the third group optical system, and the fourth group optical system are sequentially arranged from the object side toward an image side, and

the third group optical system includes a triplet lens formed by  
20 sequentially bonding a negative lens, a positive lens, and a negative lens.

29. The camera according to claim 28, wherein the camera is a digital camera.

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30. A camera comprising a zoom lens as a shooting optical system,  
wherein the zoom lens includes

a first group optical system that has a positive refracting power  
and does not move with zooming;

5 a second group optical system that has a negative refracting  
power and moves from an object side to an image side with zooming  
from wide-angle side toward telephoto side;

a third group optical system that has a positive refracting power  
and moves from the image side to the object side with zooming from the  
10 wide-angle side toward the telephoto side; and

a fourth group optical system that has a positive refracting  
power and does not move with zooming, wherein

the first group optical system, the second group optical system,  
the third group optical system, and the fourth group optical system are  
15 sequentially arranged from the object side toward an image side, and

the third group optical system includes

a triplet lens formed by sequentially bonding a negative  
lens, a positive lens, and a negative lens; and

at least one positive lens at each of the object side and  
20 the image side of the triplet lens.

31. The camera according to claim 30, wherein the camera is a  
digital camera.

32. A camera comprising a zoom lens as a shooting optical system,  
wherein the zoom lens includes
- a first group optical system that has a positive refracting power  
and does not move with zooming;
  - 5 a second group optical system that has a negative refracting  
power and moves from an object side toward an image side with  
zooming from wide-angle side toward telephoto side;
  - a third group optical system that has a positive refracting power  
and moves from the image side to the object side with zooming from the  
10 wide-angle side toward the telephoto side; and
  - a fourth group optical system that has a positive refracting  
power and moves accordingly with zooming, wherein
  - the first group optical system, the second group optical system,  
the third group optical system, and the fourth group optical system are  
15 sequentially arranged from the object side toward an image side, and
  - the third group optical system includes a triplet lens formed by  
sequentially bonding a negative lens, a positive lens, and a negative  
lens.
- 20 33. The camera according to claim 32, wherein the camera is a  
digital camera.
34. A camera comprising a zoom lens as a shooting optical system,  
wherein the zoom lens includes
- 25 a first group optical system having a positive refracting power;

a second group optical system having a negative refracting power;

a third group optical system having a positive refracting power;

a fourth group optical system having a positive refracting power;

5 a fifth group optical system having a positive refracting power;

and

a diaphragm arranged at an object side of the third group optical system, wherein

the first group optical system, the second group optical system,  
10 the third group optical system, the fourth group optical system, and the fifth group optical system are sequentially arranged from the object side toward an image side,

at least the second group optical system and the fourth group optical system move with zooming from short focal-length side toward  
15 long focal-length side, and

the second group optical system includes a triplet lens formed by sequentially bonding a negative lens, a positive lens, and a negative lens from the object side.

20 35. The camera according to claim 34, wherein the camera is a digital camera.

36. A mobile information terminal comprising a zoom lens as a shooting optical system for a camera unit, wherein the zoom lens  
25 includes

a first group optical system having a positive refracting power;  
a second group optical system having a negative refracting  
power;  
a third group optical system having a positive refracting power;  
5 and  
a diaphragm that moves toward an object side integrally with the  
third group optical system, wherein  
the first group optical system, the second group optical system,  
and the third group optical system are sequentially arranged from the  
10 object side toward an image side,  
at least the first group optical system and the third group optical  
system moves in such a manner that a distance between the first group  
optical system and the second group optical system becomes minimum  
at a short focal-length side, and a distance between the second group  
15 optical system and the third group optical system becomes minimum at  
a long focal-length side, and  
the third group optical system includes a triplet lens formed by  
sequentially bonding a negative lens, a positive lens, and a negative  
lens.

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37. A mobile information terminal comprising a zoom lens as a  
shooting optical system for a camera unit, wherein the zoom lens  
includes  
a first group optical system that has a positive refracting power  
25 and does not move with zooming;

a second group optical system that has a negative refracting power and moves from an object side toward an image side with zooming from wide-angle side toward telephoto side;

a third group optical system that has a positive refracting power  
5 and moves from the image side to the object side with zooming from the wide-angle side toward the telephoto side; and

a fourth group optical system that has a positive refracting power and does not move with zooming, wherein

the first group optical system, the second group optical system,  
10 the third group optical system, and the fourth group optical system are sequentially arranged from the object side toward an image side, and

the third group optical system includes a triplet lens formed by sequentially bonding a negative lens, a positive lens, and a negative lens.

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38. A mobile information terminal comprising a zoom lens as a shooting optical system for a camera unit, wherein the zoom lens includes

a first group optical system that has a positive refracting power  
20 and does not move with zooming;

a second group optical system that has a negative refracting power and moves from an object side to an image side with zooming from wide-angle side toward telephoto side;

a third group optical system that has a positive refracting power  
25 and moves from the image side to the object side with zooming from the

wide-angle side toward the telephoto side; and

a fourth group optical system that has a positive refracting power and does not move with zooming, wherein

the first group optical system, the second group optical system,  
5 the third group optical system, and the fourth group optical system are sequentially arranged from the object side toward an image side, and the third group optical system includes

a triplet lens formed by sequentially bonding a negative lens, a positive lens, and a negative lens; and

10 at least one positive lens at each of the object side and the image side of the triplet lens.

39. A mobile information terminal comprising a zoom lens as a shooting optical system for a camera unit, wherein the zoom lens  
15 includes

a first group optical system that has a positive refracting power and does not move with zooming;

a second group optical system that has a negative refracting power and moves from an object side toward an image side with  
20 zooming from wide-angle side toward telephoto side;

a third group optical system that has a positive refracting power and moves from the image side to the object side with zooming from the wide-angle side toward the telephoto side; and

a fourth group optical system that has a positive refracting  
25 power and moves accordingly with zooming, wherein



the first group optical system, the second group optical system, the third group optical system, and the fourth group optical system are sequentially arranged from the object side toward an image side, and

the third group optical system includes a triplet lens formed by sequentially bonding a negative lens, a positive lens, and a negative lens.

40. A mobile information terminal comprising a zoom lens as a shooting optical system for a camera unit, wherein the zoom lens includes

a first group optical system having a positive refracting power;

a second group optical system having a negative refracting power;

a third group optical system having a positive refracting power;

a fourth group optical system having a positive refracting power;

a fifth group optical system having a positive refracting power;

and

a diaphragm arranged at an object side of the third group optical system, wherein

the first group optical system, the second group optical system, the third group optical system, the fourth group optical system, and the fifth group optical system are sequentially arranged from the object side toward an image side,

at least the second group optical system and the fourth group optical system move with zooming from short focal-length side toward

long focal-length side, and

the second group optical system includes a triplet lens formed by sequentially bonding a negative lens, a positive lens, and a negative lens from the object side.

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